THE APPLICATION OF WIND INFORMATION TO THE URBAN PLANNING OF HONG KONG

Chao REN[1], Edward NG[1], Lutz KATZSCHNER[2], Jimmy FUNG[3]

[1] School of Architecture, The Chinese University of Hong Kong, Hong Kong
[2] Dept. of Landscape, Architecture & Urban Planning, Kassel University, Kassel, Germany
[3] Dept. of Mathematics, Hong Kong University of Science and Technology, Hong Kong

ABSTRACT: The paper focuses on the application of wind information to the urban planning of Hong Kong. Firstly, it reviews related studies in Germany and Japan. Secondly, based on the observed wind data from the Hong Kong Observatory (HKO) stations and the MM5/CALMET model simulations (by researchers of HKUST), the data is coded and mapped on to the GIS based UC-AnMap of Hong Kong providing a spatial understanding suitable for further evaluation. The important wind data [summer months (June-August) of Hong Kong] is the main information basis of expert evaluation. Additional information such as the annual wind data of Hong Kong is also collated for background reference. Together with the topographical information, greenery and ground roughness information, the wind data is evaluated and summarized to become the wind information layer of the Urban Climatic Map (or Klimaatlas) of Hong Kong. Finally, the expertly evaluated wind information result is incorporated into the Hong Kong's Urban Climatic Analysis Map. This forms the basis of understanding leading to the Urban Climatic Planning Recommendation Map of Hong Kong and climatic planning advice. Read these notes carefully all the way through and follow them as precisely as possible.
Keywords: Wind Information, Urban Planning, Urban Climatic Map, Hong Kong

INTRODUCTION

Hong Kong is located along the southern coast of China. Although it is only about 1000km^2 in area, the topography in Hong Kong is characterized by 75% of it being mountainous (with the highest peak of 975m), complex coastline and numerous islands (Chiu & So, 1986). Because of high density and in-homogenous urban morphology, thus, the wind environment in Hong Kong is complex. Now, more and more urban planners and architects have concerned about the urban air ventilation condition in Hong Kong. There is a need to better understand the wind conditions of Hong Kong.

Firstly, the paper reviews related studies in Germany and Japan. We aim to understand the methodology and the kind of wind data typically used for urban climatic application into urban design and planning. Secondly, based on the observed wind data from the Hong Kong Observatory (HKO) stations and the MM5/CALMET model simulations [1-2], the data is coded and mapped on to the GIS based UC-AnMap of Hong Kong providing a spatial understanding suitable for further evaluation. The important wind data (summer months (June-August) of Hong Kong) is the main information basis of expert evaluation. Additional information such as the annual wind data of Hong Kong is also collated for background reference. Together with the topographical information, greenery and ground roughness information, the wind data is evaluated and summarized to become the wind information layer of the UCMap of Hong Kong. Finally, the expertly evaluated wind information result is incorporated into the Hong Kong's UC-AnMap. This forms the basis of understanding leading to the UC-ReMap of Hong Kong and climatic planning advice.

a: satellite image of Hong Kong;

b: high-density urban morphology of Hong Kong

Figure 1: Hong Kong's topography and urban morphology

REVIEW

Pioneering works in Germany and Japan provide the basis and framework of utilising wind information in UCMap studies to guide the urban planning [3-4]. According to these desktop studies, some useful lessons and research experience shown below have been learnt.

- Wind data is typically collated from observatory data – especially stations in the city. Model simulated data can be used to supplement it.
- For planning purposes, the collated wind data is expertly evaluated taking into account topography, land use, water body and greenery understanding of the city and its surrounding areas.

- For urban air ventilation, the background wind, localized land and sea breezes (if any), topography affected channeling and valley winds (if any), cold air production (if any), cool air drainage (if any) and downhill air movement (if any) are expertly evaluated.
- Key wind directions, air circulations and ventilation areas are then coded onto the wind information layer of the Urban Climatic Analysis Map (UC-AnMap). This forms the basis of preparing the Urban Climatic Planning Recommendation Map.

METHOD

First, meso-scale wind data based on MM5/CALMET model simulation is provided by researchers of HKUST. For understanding local-scale wind pattern, a representation of wind data from 40 Hong Kong Observatory (HKO) stations has been assembled. Due to HK hilly topographical condition, topography, land use and greenery information are also collected from Planning Dept. of HK government and taken into account. Secondly in line with international practice, especially the experience from Germany and Japan, the collected wind data and information are expertly evaluated. Key issues of consideration includes the background wind, localized land and sea breezes, topographically influenced (channeling) winds, and topographically influenced (downhill (katabatic)) air movements. Finally, based on the analysis and evaluation, the wind information layer can be developed. In this map, wind information is classified into wind regions, summer prevailing wind directions, sea breezes and downhill air movements, which can be used and read by planners. The key framework is shown in Figure 2.

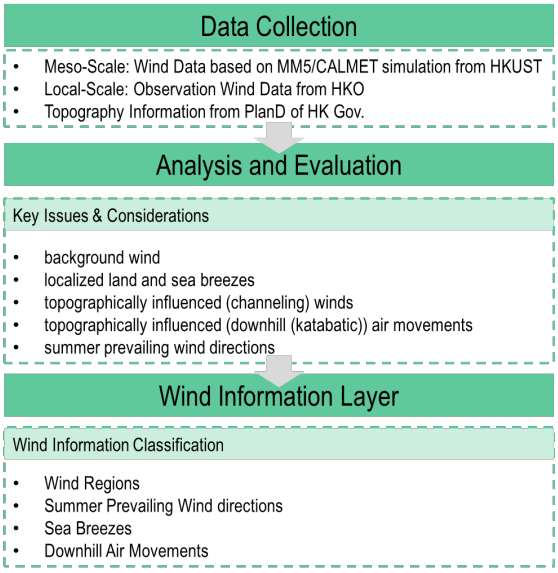

Figure 2: Diagram of Key Framework

Meta-data and wind roses of selected 38 stations have been superimposed onto Hong Kong's topographical map as shown in Figure 3. This gives an overall spatial picture of Hong Kong's territorial wind environment taking into account the topographical and surrounding land-sea characteristics. Considering average building height of Hong Kong, the MM5 data at 60m is used in this study.

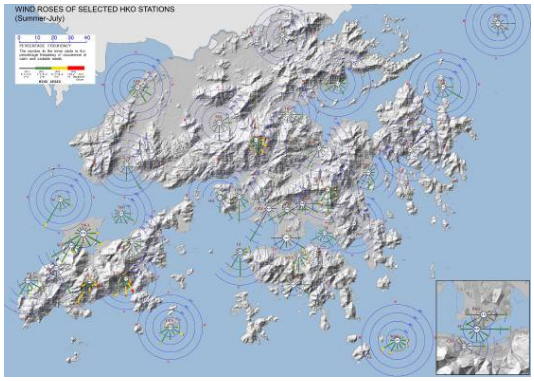

Figure 3: July wind roses of HKO stations – with topography background

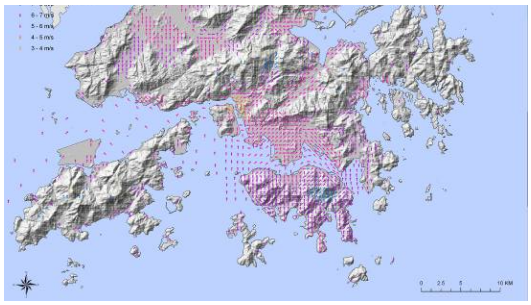

Figure 4: Prevailing summer (2004 Jun-Aug) wind directions based on MM5/CALMET simulation – with topography background.

For the Wind Information Layer of Hong Kong, the definition of the boundaries of different wind regions is mainly based on expert evaluation of the territorial wind information and topography information. Different wind regions are shown in different colors in the wind information layer (Figure 7) and their names are symbolized as C1, C2, C3, C4, D, V, SE, E and S. In each wind region, there are one or two big black wind arrows, which show the key wind directions. For the area of sea breeze and downhill air movements, only those beneficial for urban areas are presented in the wind information layer.

We focus on the summer months (Jun-Aug) – the annual wind has also been understood for reference. As explained earlier, the 4 key considerations are factored:
(1) Background wind, and
(2) Localized land and sea breezes,
(3) Topographically influenced (channeling) winds,
(4) Topographically influenced (downhill (katabatic)) air movements

(1) and (3) are to be considered together as they can be regarded as mechanically forced. (2) is localized and is time dependent. This study assumes an afternoon condition when the sea breezes are more important to consider. (4) is also localized and is related to the topography, vegetation, and the cool air production areas of the slopes. The outcome of the wind information evaluation is illustrated as Figure 5.

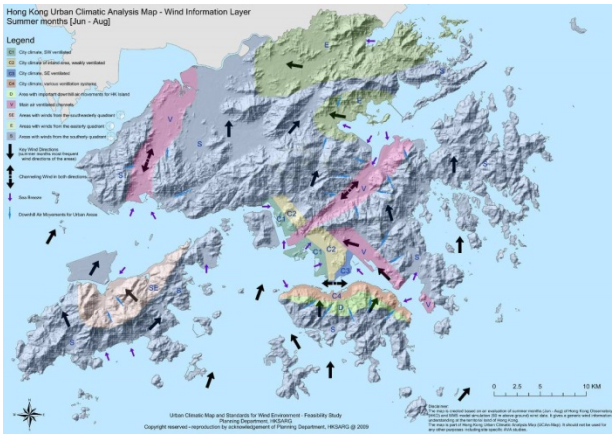

Figure 5: Wind Information Layer

ANALYSIS AND DISCUSSION

The data collation, assembly and codification, and the expert evaluation employed in this study follow a methodology typically employed conducting Urban Climatic Map studies in Germany. Various wind data is simplified as key Wind Information for works on urban climatic planning recommendations.

The study relies on data from the existing HKO stations. Further intra-urban observation stations would assist a better understanding of the more localized wind events, like the land and sea breezes, downhill air movements. Higher data density spatially within the urban areas can also be useful. Currently, only 2004 MM5/CALMET is available to the study team. Although it is a start, a multi-year (say 3-5 years) dataset would be more representative.

The wind information layer is part of Hong Kong UC-AnMap. It should not be used for any other purposes including site specific air ventilation assessment (AVA) studies. It gives a generic wind information understanding at the territorial land of Hong Kong. It will be incorporated into UCAnMap and UCReMap. Some useful results and understanding from the wind information layer will be presented in Urban Climatic Planning Recommendations at Outline Zoning Plan (OZP) level, which could help planners to design better.

IMPLIMENTATION

The findings of the wind information layer will be added into the updated Chapter 11 of Hong Kong Planning Standard and Guidelines (HKPSG) in 2013. This gives an indication as to the extend project proponents may need to consider when designing towards a better urban environment [5]. The Government will lead the industry by setting an example. The newly re-planned Old Kai Tak Airport will demonstrate that commitment (Figure 6).

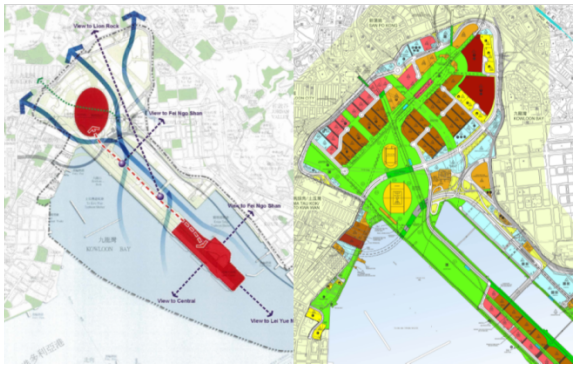

Figure 6: The layout of master plan of Kai Tak Areas

This will be followed with the planning of the New Development Areas (NDAs). The new satellite settlements, each with rough half a million residents, will be planned taking into account these findings from the Wind Information Layer.

CONCLUSION

The wind information layer gives a generic wind information understanding at the territorial land of Hong Kong. It will be incorporated into UCAn-Map and UCReMap. Some useful results and understanding from the wind information layer will be presented in Urban Climatic Planning Recommendations at OZP level, which could help planners to design better.

ACKNOWLEDGEMENTS

The project is funded by the Planning Department HKSAR Government. Apart from the researchers at CUHK, thanks are due to colleagues in the Hong Kong Government: Civil Engineering Development Department, Hong Kong Observatory, Environmental Protection Department, Housing Department, Buildings Department, Lands Department, Architectural Services Department, Housing, Planning and Lands Bureau, and Sustainable Development Unit of the Chief Secretary for Administration's Office, and last but not least, the Planning Department for managing the study and which has been in partnership with the researchers throughout the study.

REFERENCES

1. Yim, S. H. L., J. C. H. Fung, A. K. H. Lau, & S. C. Ko. (2007). Developing a high-resolution wind map for a complex terrain with a coupled MM5/CALMET system. *Journal of Geophysical Research*, 112: P.1-15

2. Yim S. H., Fung J. C., Lau A. K.(2009). Mesoscale Simulation of Year-to-Year Variation of Wind Power Potential over Southern China. *Energies*. 2(2): p.340-361

3. Baumüller, J., Hoffmann, U., & Reuter, U. 1992. Climate booklet for urban development, Ministry of Economy Baden-Wuerttemberg (Wirtschaftsministerium), Environmental Protection Department (Amt für Umweltschutz).

4. Summit meeting of nine Tokyo-area governors and mayors, (2007). The Study Report of Air Path: investigation and research, Tokyo, Japan.

5. Ng, E. (2012).Towards Planning and Practical Understanding of the Need for Meteorological and Climatic Information in the Design of High-density Cities: A Case-based study of Hong Kong. *International Journal of Climatology*, 32 (4): p.582-598.